

## DIVISION 16 ELECTRICAL AND INSTRUMENTATION

## SECTION 16913

**PLC APPLICATIONS PROGRAMMING****PART 1 GENERAL****1.1 SECTION INCLUDES**

- A. Applications Programming Software for Programmable Logic Controllers at the Filter Plant, Reservoir Influent Flowmeter, Tyler Dr. Tank, Winding Way Tank, and Forest View Well. Programming for the processors is herein referred to as PLC programming.
- B. Work specified in Electrical Section 16010.
- C. Configuration and graphic setup for the Touchscreen and SCADA at the Filter Plant.

**1.2 RELATED SECTIONS**

- A. Division 16.

**1.3 SUBMITTALS**

- A. Provide submittals per Electrical Section 16010 – SUBMITTAL AND DRAWING REQUIREMENTS.
- B. Provide the following three separate programmable controller (PLC), Operator
- C. Interface OI, and SCADA graphics software submittals:
  - 1. Preliminary PLC, OI, & SCADA OI Submittal – PLC, OI, & PC SCADA OI hardware and software configuration shall be submitted at 10 percent complete level for a preliminary courtesy check by the District. This check will not entail a detailed check of all performance features and will not absolve the Contractor of his responsibilities. It is required that the PLC applications software be fully annotated with complete description of control logic, explanation of symbology and convention including legend list. Provide color printout of SCADA OI graphic screen format proposed.
  - 2. Formal PLC, OI, & SCADA OI Submittal - This is the submittal for review per Contract Requirements and is to be submitted after approval by District of the preliminary PLC, OI, & SCADA OI submittal. This submittal shall be approved for basic content (not for correctness of ladder logic code).
  - 3. Final PLC, OI, & SCADA OI Submittal - This submittal will be part of O&M manual. The software documentation shall be the as-finished records of the formal PLC, OI, & SCADA OI submittal and other documents used during testing and startup.
- D. Three (3) weeks (minimum) prior to the start of the factory tests, the Contractor shall submit for approval the following software information for the "Formal" submittal:
  - 1. Submit PLC software submittal showing the structure of the applications programs and the purpose of each module.
    - a. English description, flowchart, and index of each major ladder logic program section illustrating subsection of program organization.
    - b. Include high level block diagram and English description of PLC file structure.
    - c. Include comments for each block of code explaining purpose of individual lines.
    - d. Include a listing of all setpoints with their corresponding English description.
    - e. Manual shall include complete explanation on the set-up and configuration of the PLC hardware and software.
    - f. Include a description of the PLC diagnostic and Ladder Logic programming functions available through the diagnostic computer.
    - g. Include an English description of each Control Strategy describing intent of operation. This shall be separate from PLC printout. Description shall include summary table listing PLC addresses corresponding to all tagnames listed or implied in Section 16918 - PLC Control Strategies.
  - 2. PLC software submittal documentation shall include machine printed ladder diagrams and listings. This documentation shall detail the following:
    - a. The ladder diagrams shall be drawn with the contacts on the left side of the coil on each rung. Each contact and coil shall have a typed description of its function. A line-by-line typewritten description of the each rung shall be given on the ladder diagrams. Each I/O point in the ladder logic

- shall be shown with its corresponding I/O "tagname"; i.e. LA151LL for digital input of Tank 800 Lo Lo Level Switch.
- b. An "Input/Output List," tabulating the module location, terminal points, channel number, address number, point type, point voltage, input/output designation "nickname" and/or number, and a textual description for each item of input and output.
  - c. A "Constant Memory Assignment List," tabulating the assigned register name, location number, and textual description for each constant stored in memory.
  - d. A "Variable Memory Assignment List," tabulating the assigned register name, location number, and textual description for each variable stored in memory.
  - e. A "Cross Reference List," tabulating the rung locations for the usage of each symbol throughout the ladder logic. For each coil, the rung locations for each of its contacts shall be listed. For each input all the rungs in the ladder logic in which it is used shall be listed.
  - f. A "Memory Map and Usage List," tabulating the allocation of CPU memory. This listing shall identify the contents of the reserved memory and what areas are unused.
  - g. A brief description on a page preceding the ladder diagram listings, describing all symbols and functions used on the ladder diagram.
  - h. A written description of lookup table data, for each lookup table. Include the source of data used for each table.
  - i. A brief description, on each page of "Special Function" listings, including:
    - 1) A textual description of input variables and/or constants.
    - 2) A textual description of output variables and/or constants.
    - 3) A textual description of the functions.
    - 4) Reference(s) to any specific locations on the ladder diagram listings where the special functions apply.
3. Submittal content shall comply with the following:
    - a. Contain complete and separate data files shall be provided for each PLC applications program.
    - b. Applications program files shall be capable of being uploaded from the PLC and separate comment files shall be capable of being merged with the code for program maintenance.
    - c. Program files shall be stored in a format that can be retrieved, edited, merged with comment files, and downloaded to PLC using the programming software.
    - d. Listing of all setpoints with proposed initial numeric entry values and corresponding Engineering Units for control strategies. Submit spreadsheet style setpoint list for all pressure, flow, level, timers, etc.
    - e. Listing of all digital and analog registers, bits, timers etc., their respective description, I/O tagnames, and full addresses for development of factory test screen.
    - f. Complete commented ladder logic program.
  4. Submittal of color printout of all SCADA OI graphic screens proposed and their associated database.
  5. Submit software documentation demonstrating compliance with Portability and Maintainability requirements specified in this Section, and demonstrating understanding of control software requirements.
  6. The Contractor shall submit for approval the resume of the application programmer listing all relevant experience. Application programmer that does not have relevant experience to this project will be rejected by Engineer and the Contractor shall submit the resume of a qualified application programmer.
- E. Submittals shall be placed in three ring binders with index. All copies shall be clear and legible. PLC Data files shall be provided with an index and proper identification and cross-referencing.
  - F. Exceptions to the Contract control strategies shall be clearly defined by the equipment supplier. Description of changes shall contain sufficient details so a proper evaluation may be made by the Engineer.
  - G. The Supplier shall coordinate software submittals with the work so that project will not be delayed. This coordination shall include scheduling the different categories of submittals, so that one will not be delayed for lack of coordination with another.
  - H. No PLC, OI, or SCADA software will be allowed to be installed at the job site until the submittal for such items has been favorably reviewed by the Engineer and witness factory tests have been completed.

#### **1.4 OPERATION AND MAINTENANCE DATA**

- A. Submit software operations and maintenance manual per Electrical Section 16010 – MAINTENANCE AND OPERATING INSTRUCTIONS.
- B. Include in software operations and maintenance manual all information required under "Submittals" in an as-finished document.

- C. Submit original software operations and maintenance manuals for PLC, OI, & SCADA OI hardware and software, no copies. Include documentation for firmware modules and major software items.

### 1.5 PORTABILITY

- A. Supply software that is modular in design with programs and data tables maintained as unique entities, each easily expanded or modified.
- B. Design and code programs to operate correctly regardless of the size of the system database, and so that changes to the system database do not require changes in program logic.
- C. PLC programs shall be setup for the following:
  1. Complete and separate data files shall be provided for each applications program.
  2. Applications program files shall be capable of being uploaded to the PLC and separate comment files shall be capable of being merged with the code for program maintenance.
  3. Program files shall be stored in a format that can be retrieved, edited, merged with comment files, and downloaded to PLC using the programming software.
  4. Programmed with Idec WindLDR, compatible with Windows 7 operating system.
- D. Wonderware graphics shall be setup using the latest version of Wonderware.

### 1.6 MAINTAINABILITY

- A. Design and code programs to allow the District to maintain software over the life of the system. This includes the following requirements:
  1. Clearly comment code. Include module headers detailing the purpose of the module, programmer name, date of last revision, revision history, and description of sequence of events.
  2. Provide an "Input/Output List," tabulating the module location, terminal points, channel number, address number, point type, point voltage, input/output designation "tagname" as shown on P&ID and/or number, and a textual description for each item of input and output.
  3. Provide cross reference tables with tagnames and I/O addresses to summarize usage of AIs, AOs, DIs, DOs, setpoints, coils, contacts, timers, etc. These tables shall indicate the line numbers where AIs, AOs, DIs, DOs, setpoints, coils, contacts, timers, etc are located with the ladder logic program.
- B. All software, including diagnostic, configuration and applications programming software shall be licensed directly to and become the sole property of the District for their use on this and future District projects.
- C. No software or documentation shall be labeled proprietary.
- D. Provide complete hardware and software manuals describing how to use the configuration software.

### 1.7 MEDIUM

- A. Provide two (2) sets of PLC/OI/SCADA applications programs on CDs (CD-ROMS), with each software submittal and at the end of the project for as-programmed final documentation for O&M manuals. Each disk shall have a typed label clearly stating the contents, date, filenames and submittal (i.e. initial or as-programmed final).
- B. A hard copy listings of PLC/ OI/SCADA applications programs (with comments) shall be printed with standard laser print 8 1/2" x 11" paper and supplied with each submittal and for as-programmed final documentation for O&M manuals. Copy method shall not cut off any parts of ladder logic and comments. Print shall be sized so that the complete ladder logic rung fits on one sheet, rungs extending to multiple sheets will not be accepted and will be returned without review.

## PART 2 PRODUCTS

### 2.1 APPLICATIONS PROGRAM

- A. Provide applications programs in the PLC to implement the following control strategies. The Contractor is responsible to provide an application program that meets the intent of the descriptions given along with any additional implementations for a fully operational system at no additional cost to District.
- B. PLC, OI, & SCADA OI Software Configuration: The Supplier shall provide the PLC, OI, & SCADA OI completely configured and programmed for the monitoring and control of the process. The PLC, OI, & SCADA OI shall be setup as defined herein. The PLC, OI, & SCADA OI shall be ready to be placed in operation at the time of factory test. The programming, setup and configuration of the PLC, OI, & SCADA OI shall be done by the PLC, OI, & SCADA OI supplier. All programming shall be performed by an application programmer with prior experience on similar PLC, OI, & SCADA OI projects. District reserves the right to judge if the application programmer assigned to this project is adequate for the task. If the programming performed is

- deemed inadequate by District, then the supplier shall provide a qualified application programmer to meet these requirements.
- C. The setup details given for the PLC, OI, & SCADA OI are intended as guidelines for the supplier to use to configure the system. The setup details were prepared with the available information on the software package and may not be the best way to accomplish the task. Errors and omissions in these details shall be the supplier's responsibility to correct, at no additional cost to District. The supplier shall meet the intent of the setup specified, making modifications as necessary to provide an operational system, at no additional cost to the District.
  - D. The setup details given for the PLC are intended as guidelines for the supplier to use to configure the system. The setup details were prepared with the available information on the software package and may not be the best way to accomplish the task. Errors and omissions in these details shall be the suppliers responsibility to correct, at no additional cost to District. The supplier shall meet the intent of the setup specified, making modifications as necessary to provide an operational system, at no additional charge to the District.
  - E. There are two types of alarms; variable alarms and discrete alarm.
    1. Variable alarms are alarms where a variable input (i.e. level, pressure, etc.) has exceeded its predetermined high/low setpoint. Each variable alarm will have a time delay to prevent false alarms and an alarm enable/disable condition.
    2. Discrete alarms are alarms where a condition has occurred (i.e. pump fail, etc.). Each discrete alarm shall have a time delay to prevent false alarms and an alarm enable/disable condition.
  - F. All referenced setpoints shall be displayed and changeable on existing Operator Interface at the Water Treatment Plant.
  - G. The PLC ladder logic applications program and OI graphic setup shall meet the intent of the Contract Drawings. The following additional program functions shall be provided (minimum):
    1. Enable/disable and settable time delays for all alarms.
    2. Scaling to engineering values of all variables:
      - a. Level in 1/10s FT resolution.
      - b. Pressure in 1/10s PSI resolution.
    3. Transducer fail alarms for all analog inputs.
    4. All setpoints and registers shall be adjustable from Central SCADA at WTP.
    5. All resets and acknowledge pushbuttons shall be settable from Central SCADA at WTP.
  - H. Operator Interface Configuration
    1. The following shall be provided on the SCADA display for all ladder logic program control strategies:
      - a. Graphic screen displaying station main parameters in process flow format.
      - b. Setup control parameter screen listing all setpoint registers.
      - c. Alarm summary screens listing all alarms.
      - d. Acknowledge button to acknowledge alarms displayed on OI.
      - e. All values displayed with engineering units.
      - f. Analog values with the resolution listed above
      - g. Display indicating a new alarm no matter which screen is currently displayed.
      - h. Jump button displayed on all screens to go to a menu screen listing jumps to all screens.
      - i. Jump button displayed on all screens to go to the previous screen.
      - j. "Next" button displayed on all screens to go to the following screen.
      - k. Text accompanying any changes in color display (i.e., green – "RUN", red – "OFF", etc.).
      - l. Setup color convention to be used:
        - 1) Background colors:
          - a) Window - Black.
          - b) Changeable variable points - Pale Yellow.
          - c) Non-Changeable variable points - Light Blue.
        - 2) Control Switch Colors
          - a) Hand - Red.
          - b) Off - Grey.
          - c) Auto - Green.
        - 3) Pump and Equipment Colors
          - a) Run - Green.
          - b) Off - Red.
          - c) Fail - Gold.
          - d) Ready/Available - White.

- 4) Water Valve Colors
    - a) Closed - Red
    - b) Modulating - Purple.
    - c) Fully Open - Green.
    - d) Undetermined - Grey.
  - 5) Circuit Breaker Colors
    - a) Closed - Green.
    - b) Open - Red.
  - 6) Relay Logic Colors
    - a) Closed Relay Contact - Green
    - b) Open Relay Contact - Red.
2. Configure Wonderware Graphics on SCADA computer. This will include creating and testing:
- a. SCADA database of tagnames that are used in the Contract Documents control strategies shown on Contract Drawings and transferred between processors.
  - b. Graphic screens representing the plant process flow. Graphic screen of the plant overview will also be updated.
  - c. Control folders listing process values and control setpoints.
  - d. Alarm annunciator screens similar to standard mechanical alarm annunciators.
  - e. PLC maintenance screens representing for PLC input and output cards. f. Realtime (1, 4, 8 & 12 hour) and Historical Trends of process variables. g. Autodialer callout on new alarms. A process values menu will be developed with the Operators so they may access key values and status.

## 2.2 CONTROL STRATEGIES

- A. Provide applications programs in the PLC/OI/SCADA to implement the control strategies specified herein. The Contractor is responsible to provide an application program that meets the intent of the descriptions given along any additional implementations for a fully operational system at no additional cost to the District.

## PART 3 EXECUTION

### 3.1 SOFTWARE DEVELOPMENT

- A. General Programming
1. The program structure shall utilize a main program file, subroutine files, a fault routine file, and an I/O configuration control file.
  2. Program logic shall be separated by function into subroutine files. The main program file shall execute subroutine calls as required to properly implement the control strategy. The following functions should be implemented in separate subroutine files:
    - a. Analog and discrete input processing.
    - b. Analog and discrete output processing.
    - c. Miscellaneous monitor, alarm and control.
    - d. Supervisory control and data acquisition communications.
  3. The fault routine file shall be executed immediately after the system is powered up and in response to major faults, providing a programmed response to these conditions and report to SCADA, the type of fault.
  4. Analog input out-of-range conditions shall be monitored and alarmed by the relay ladder logic.
  5. All program rungs shall be commented clearly. The first rung comment of every file should include a brief description of the program file function in addition to the rung comment.
  6. All program instructions shall be commented clearly.
  7. Memory locations specifically for displaying at SCADA shall be commented with the item description + "for SCADA". Analog data shall include the scaling used by the analog module as part of the comment (e.g., Flow 1 (0-2000, raw) for SCADA).
  8. The ladder diagrams shall be provided as specified herein.
- B. Analog Input & Output I/O Processing:
1. Data Format shall be read from the module in two's complement data format.
  2. Scaling shall be accomplished within the module setup for all analog inputs and outputs in engineering units. (e.g., 0-200 E.U. = 0-2000 raw data).
  3. All internal setpoints used in conjunction with analog data shall incorporate the same scale.

4. Physical I/O addresses (i.e. I:001/00 for a digital input) shall be placed on their corresponding loop and elementary diagrams.
  5. The data out-of-range bits provided by the analog modules shall be utilized for alarming purposes within the ladder program.
- C. PLC Memory Register Design
1. To maximize the efficiency in which data is transferred between PLCs and between PLCs and the SCADA, the ladder logic program shall be designed to use contiguous memory locations within the PLC. This may include but is not limited to moving data such as discrete I/O into 16-bit integer words.
  2. Efficient use of bit instructions shall be used in place of word logic whenever possible to reduce memory usage.
- D. Before beginning SCADA & PLC/OI software development, meet with the District for a four-hour Design Definition Meeting at the District's facility.
1. Ensure that the Contractor Project Manager, System Supplier Engineer, System Supplier SCADA & PLC/OI software programmer, Engineer & District are in attendance.
  2. Discuss SCADA, OI, & PLC format, programming and setup requirements to ensure that parties involved have a clear understanding of the Contract requirements. This discussion is to cover graphic screen layout, color conventions, text display menu system, PLC ladder logic etc.
  3. System Supplier to provide schedule for Preliminary Design Review and Critical Design Review.
- E. Meet with the District for a 4-hour SCADA & PLC/OI Preliminary Design Review meeting at the District's facility.
1. Ensure that the Contractor Project Manager, System Supplier Engineer, System Supplier SCADA & PLC/OI software programmer, and Engineer & District are in attendance.
  2. Provide SCADA & PLC/OI software preliminary design submittals for review and discussion 10 working days prior to meeting.
  3. System Supplier to demonstrate SCADA screen color and graphic layout by bringing a configured PLC and PC loaded with modified SCADA graphics to the meeting.
  4. System Supplier to demonstrate Panelview OI color and graphic layout by bringing a configured PLC and PanelView to the meeting.
  5. System Supplier to demonstrate complete understanding of PLC control sequence of operations and SCADA/OI setup.
  6. System Supplier to assign action items with required completion date.
  7. Contractor to submit report of completed action items to the District on or before designated date.
- F. Meet with the District for a 4-hour SCADA & PLC/OI Critical Design Review meeting at the District's facility prior to start of any factory test.
1. Ensure that the Contractor Project Manager, System Supplier Engineer, System Supplier SCADA & PLC/OI software programmer, and Engineer and District are in attendance.
  2. Provide preliminary SCADA & PLC/OI Software Operations and Maintenance Manual.
  3. System Supplier to demonstrate the complete SCADA & PLC/OI setup. All station display and setpoint parameters will be checked for completeness by bringing a configured PLC/OI and PC loaded with modified SCADA graphics to the meeting.
  4. System Supplier to demonstrate all SCADA and Panelview screens for review and comment.
  5. System Supplier to assign action items with required completion date.
  6. Contractor to submit report of completed action items to the District on or before designated date.
- G. The Contractor shall include in his bid price an additional 120 hours of PLC/OI program and SCADA Operator Interface graphic changes to be designated during testing and start-up. Programming changes made during factory testing shall not be deducted from these hours unless agreed upon by Engineer. Field program changes shall be made by original programmer within two (2) working days after notification in writing by Engineer. Failure of programmer to respond and make requested program changes within these two (2) working days will result in Owner hiring another programmer and backcharging the Contractor \$150.00 for each hour of the other programmer's time plus travel expenses. All programming configuration changes shall be performed by the original programmer and shall be made as directed by the Engineer in writing. A weekly report shall be prepared by System Supplier listing extra hour utilized, dates when work was done, description of work performed, and remaining number of extra hours. None of the hours shall be used for documentation, paperwork, travel, overhead, construction management, etc. that are not related to programming changes since this is included in the hourly rate without written approval from Engineer. All hours not used shall be allocated for additional PLC program changes as directed by Owner during the one year warranty period.

- H. No passwords shall be enabled on PLC/OI/SCADA software or hardware developed for this project. All electronic disk copies provided to District shall not have any password protection enabled on them or the software. Software submitted with password protection will be removed by District and the Contractor will be backcharged for the cost thereof.

### 3.2 WARRANTY

- A. The Contractor shall have a staff of experienced personnel available to provide service within 2 working days after given notice by District during the warranty period. Such personnel shall be capable of fully testing and diagnosing the hardware and software and implementing corrective measures. If the Contractor "fails to respond" in 2 working days, the District at its option will proceed to have the warranty work completed by other resources; the total cost for these other resources shall be reimbursed in full by the Contractor. "Fail to respond" shall be defined as: The Contractor has not shown a good faith effort and has not expended adequate resources to correct the problem. The use of other resources, as stated above, shall not change or relieve the Contractor from fulfilling the remainder of the warranty requirements.
- B. The Contractor shall warrant all electrical and instrumentation equipment & software for a period of one (1) year from date of final acceptance. Standard published warranties of equipment which exceed the preceding specified length of time shall be honored by the manufacturer or supplier.
- C. Hardware support:
1. The system supplier shall have a staff of experienced personnel available to provide service on a 2 working days notice during the warranty period. Such personnel shall be capable of fully testing and diagnosing the hardware and software delivered; and of implementing corrective measures.
- D. Software support which shall be provided by the supplier:
1. Free technical PLC, OI, & SCADA OI software and hardware configuration phone support for a period of one year after acceptance of project completion. PLC, OI, & SCADA OI phone support shall be provided directly from the group that configured the PLC, OI, & SCADA OI. Phone support shall be available between 8 a.m. and 4 p.m. Pacific Standard Time Monday through Friday.
  2. The supplier shall correct any PLC, OI, & SCADA OI software configuration error that is discovered within the warranty period, at no additional cost to District. Updated documentation for each "operation and maintenance" manual and two (2) sets of new CD of updated software shall be provided for each correction.
  3. Program changes made by District or under direction of District by others shall not relieve or void Contractor of warranty requirements for parts of software programmed under this Contract.
- E. Each time the Supplier's repair person responds to a system malfunction during the warranty period, he or she must contact the designated District maintenance supervisor for scheduling of the work, access to the jobsite, and permission to make repairs. Operation of facilities necessary to test equipment shall only be performed by or under the direction District staff. District reserves the right at its sole discretion to deny operations requested by the Supplier.
- F. Warranties shall be transferable to District.

### 3.3 TRAINING

- A. Training shall be provided as specified in Section 16010.

END OF SECTION